§22. Fabrication of MgB_2 Multifilamntary Wires Using ^{11}B Isotope Powder as the Boron Source Material

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The features of the MgB_2 compound are a higher critical temperature (T_c) of 39 K, simple binary chemical composition, lower specific gravity and relatively low cost material. We thought that MgB_2 compound will be desirable as one of the candidate materials of "low activation superconducting magnet" for a fusion reactor operated near D-T core plasma. The merits of applying to MgB_2 superconducting wire in an advanced nuclear fusion power plant system are lower induced radioactivity and higher efficiency of the cryogenic system due to the higher critical temperature (T_c) property. In the fusion reactor, the Poloidal field (PF) and feedback coils require a larger coil radius to correct the position of the plasma. These MgB2 coils contributed stable operation core D-T plasma due to the lowering of heat load by the nuclear heat generation. We already found the Cu addition using Mg_2Cu compound in the MgB_2 phase was effective to improve J_c without lowering T_c property, and J_c property of MgB_2 wire via low temperature diffusion was drastically improved under the low magnetic field region.

On the other hands, the natural boron powder as the source material has two kinds of isotopes which are boron-10 (^{10}B) and boron-11 (^{11}B). The natural isotope abundance of boron is mainly 20 wt% of ^{10}B and 80 wt% of ^{11}B. The ^{10}B pellets are used to neutron absorption material of nuclear fission reactor because it has large nuclear reaction cross-section. ^{11}B isotope is stable against the neutron irradiation without nuclear transformation. We thought that in-situ PIT process using ^{11}B isotope powder as the boron source material was suitable to enhance radio-activity of the MgB_2 superconducting wire for fusion application. We tried to fabricate in-situ PIT processed Cu addition MgB_2 multifilamentary wire using the ^{11}B isotope powder as the boron source material. Superconductivity of Cu addition MgB_2 wire was investigated.

Precursor mixture powders were made by metal Mg powder, Mg_2Cu compound and ^{11}B isotope powder (@Cambridge Isotope Laboratories, Inc.). The precursor mixture powders were tightly packed into metal Ta tubes. Wire drawing was carried out using grooved-roller and cassette-roller dies, and the precursor wires finally had a diameter of about 2.00 mm. The prepared mono-cored wire was cut to short piece wires, and they were stacked into metal Cu tube. The number of stacked mono-cored wires was 19 pieces. This stacked composite was wire drawn to a final diameter of 1.04 mm. Typical SEM image of cross-sectional area in MgB_2/Ta/Cu filamentary wire via PIT process using ^{11}B isotope powder is shown in fig.1. Sample wires were heat treated using "Low temperature diffusion process" which is various lower temperatures (450-550℃) during 200 hours in an Ar atmosphere. After heat treatment, T_c value was estimated from magnetization measurement with a Quantum Design SQUID magnetometer.

Typical magnetization (M)-temperature (T) curves by zero-field cooling method as a function of sintering temperature in MgB_2 wires using ^{11}B isotope powder is shown in fig.2. T_c value was defined by the onset of the transition on M-T curve. T_c value was obviously increased by the elevating of heat treatment temperature; 29.5 K, 36.9 K, 37.8 K, 38.0 K and 38.0 K for 450℃, 475℃, 500℃, 525℃ and 550℃, respectively. This was suggested that high T_c MgB_2 phase via PIT method using ^{11}B isotope powder promoted to form at the heat treatment above 500℃. T_c value of Cu addition MgB_2 wire made by natural B powder was obtained to about 37 K. We found that MgB_2 phase formed by ^{11}B isotope powder had higher T_c property.

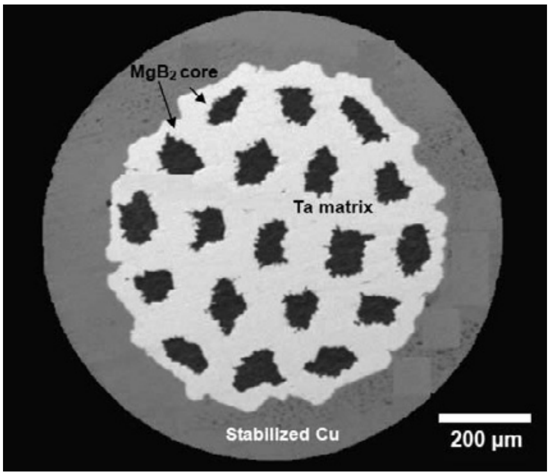

Fig.1 Typical SEM image of cross-sectional area in Cu addition MgB_2/Ta/ Cu 19 filament wire using ^{11}B isotope powder as the boron source material

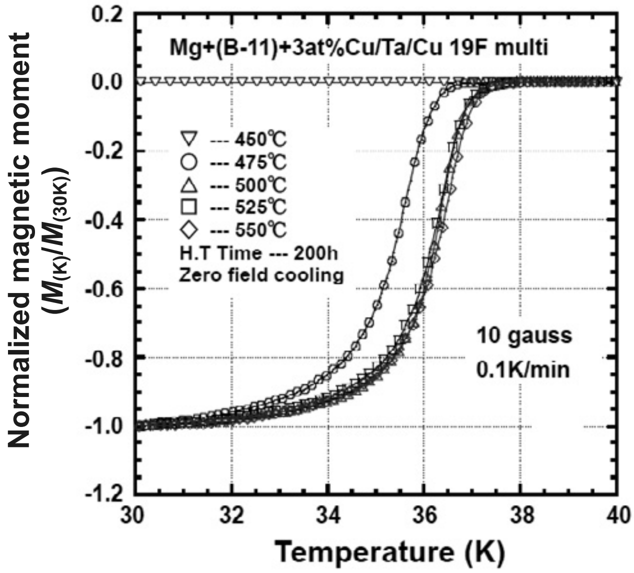

Fig.2 M-T curves by zero-field cooling method as a function of sintering temperature in MgB_2 wires using ^{11}B isotope powder